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RESEARCH ARTICLE

Consumer attitudes towards ultrasound processing and product price: Guava juice as a case study

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Abstract

Several kinds of emerging technology have begun to be applied to food processes as prospective alternatives to conventional methods. Among these, ultrasound has been used. Despite the vast literature on the subject, some important aspects, including the sensory and hedonic perception of consumers towards this technology have not been properly addressed. In this study, consumer attitudes toward expected acceptance, pricing and purchase intention of guava juice processed with ultrasound technology were analyzed by using the conjoint analysis. The holistic perception of guava juice using projective mapping was also evaluated. The results indicate that consumers have greater acceptance and purchase intention for products that inform them of the benefits of the ultrasound process, while purchase intention was mainly influenced by the lowest price. Moreover, the product information regarding the ultrasound technology -displayed on individual packages- was a predominant factor which also served as a criterion for grouping the stimuli. Overall, the information highlighting the use of ultrasound technology during the processing of guava juice did not have any negative effect on the consumers' acceptance and purchase intention. These findings can be considered as a positive indicator towards the possible application of this technology to industrial juice processing.

Keywords: ultrasound technology; food processing; conjoint analysis; projective mapping; expected acceptance; purchase intention.

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1. Introduction

Taking into account "The consumer voice" during the initial stages of the new product development process is a key factor for product success in the market (van Kleef, van Trijp, & Luning, 2005). Even though this stage is crucial for food processing, it is often disregarded or poorly executed. This is even more crucial when dealing with emerging technologies, since these face challenges when introduced and a wide range of factors influence consumer behavior and preferences (Meijer, Lähteenmäki, Stadler, & Weiss, 2021; Siegrist & Hartmann, 2020). In recent years, emerging technologies have begun to be applied in food processing, one of these being ultrasound (US). Thus, different processes and products have been widely studied with US application. In fact, it has been shown that the application of US improved the microbiological, physical, chemical quality and bioaccessibility of apple juice (Wang, Hu, & Wang, 2010; Yuan, Hu, Yue, Chen, & Lo, 2009), orange juice (Valero et al., 2007), cactus pear juice (Zafra-Rojas et al., 2013), peach juice (Rojas, Leite, Cristianini, Alvim, & Augusto, 2016), guava juice (Campoli, Rojas, do Amaral, Canniatti-Brazaca, & Augusto, 2018) and different amazon fruits (de Souza Carvalho et al., 2020). On the other hand, some authors such as Dias et al. (2015); Seydi (2020); Šimunek et al. (2013); Walkling-Ribeiro, Noci, Cronin, Lyng, & Morgan (2009) have carried out studies on the overall acceptance and sensory profile of beverages processed with ultrasound. In these studies, however, the consumers were not aware of the ultrasound technology used during the processing of the product.

Nowadays, the consumer is becoming more demanding with regards to their preferences, only choosing products that satisfy several of their needs. According to Köster

(2009) food selection is influenced by an item's sensory properties, price, nutritional properties, processing method, environmental impact, among others. In this regard, Shepherd & Raats (2006) explains that food selection is influenced mainly by three dimensions: "food", "consumer", and "context". The "food" dimension is contemplated essentially by its sensory characteristics, while the "consumer" dimension mainly considers the characteristics of each person. The dimension of "context" relates to the culture, religion, habits, among others that limit the consumption of certain kinds of foods. Concerning food dimension, it should be mentioned that the factors influencing the acceptance, purchase intention and final food selection are ascribed to both extrinsic and intrinsic factors.

The intrinsic factors comprise mostly the sensory characteristics, while the extrinsic factors, also known as "non-sensory factors", establish the first consumer-food interaction, and consequently has a strong influence on consumer food selection (Ares, Giménez, & Gámbaro, 2009). According to Jaeger (2006), the most important non-sensory factors in food selection are: convenience, price, production technology, personal health, branding, social and political issues, and contextual influences. In particular, the packaging and labeling are used as marketing tools (Santeramo et al., 2018), since these may contain selected information to be transmitted to the consumer. Therefore, package design plays a pivotal role and is of utmost importance to create packaging and labels that capture the interest of the consumer and lead to the purchase of the product (Ares & Deliza, 2010). However, as was reported by Feindt & Poortvliet (2020) processing of information on labels will interact with previous consumer attitudes, knowledge and information literacy. Indeed, several studies have been carried out on consumers' attitudes toward products with elements that make up the label, such as brand, shape, color, images, nutritional information, declared health benefits, and ecological aspects (Asioli, Næs, Øvrum, & Almli, 2016; Rosires Deliza, Macfie, & Hedderley, 2003; Silayoi & Speece, 2007; Sousa, Carvalho, & Pereira, 2020). In this context, this study aims to evaluate consumer attitudes towards the information displayed on the labels, which highlight the use of ultrasound technology during juice processing.

In addition to the technology used during the processing of food products, the price a consumer is willing to pay is also a key factor when a product is introduced to the market. Indeed, the willingness to pay more for a product processed by emerging technologies, depends on the technology's perceived benefit (Jaeger, 2006). In this regard, few studies have addressed the effect of the visual declaration of processing technology on the sensory perception, acceptance and purchase intention of these products. For instance, Cardello, Schutz, & Lesher (2007), da Costa, Deliza, Rosenthal, Hedderley, & Frewer (2000), Deliza, Rosenthal, Abadio, Silva, & Castillo (2005), Deliza, Rosenthal, & Silva (2003) and Balatsas-Lekkas, Arvola, Kotilainen, Meneses, & Pennanen (2020) studied consumer behavior towards products processed with different technologies (high pressure, irradiation, pasteurization, genetic modification, electrical pulses and cold storage), using factors that include the brand, price, and information declared on the label related to the technology used, considering their risks and benefits. Note that in the studies above, consumer behavior towards products processed with emerging technologies relies on the conjoint analysis approach. Conjoint analysis is an established and validated technique, commonly used in marketing (Calegari, Barbosa, Marodin, & Fettermann, 2018; Claret et al., 2012), which studies the factors that modify the behavior of the consumer, specifically purchase intention. Depending on the experimental design, different stimuli are created and, subsequently, presented to consumers, who will have to choose or qualify the stimuli according to their criteria (Deliza et al., 2005). Finally, the relative importance of each factor and the usefulness of the levels of each factor were obtained (Raz et al., 2008).

To the best of our knowledge, so far there have been no studies addressing the impact of juice processing with US on consumer behavior. Thus, this study aims to evaluate consumer behavior towards US usage for processing (information displayed on the package label) and price, considering expected acceptance, purchase intention, and holistic guava juice perception.

2. Materials and methods

2.1 Consumers

This study was conducted entirely online, following the current trend predicted by Meiselman (2013), who suggested that internet-based questionnaires would replace, partially, studies conducted in the laboratory. The questionnaire was prepared in Brazilian Portuguese and was available for three weeks, yielding the participation of a total of 156 consumers. However, only 105 consumers reported being regular consumers of guava juice. Of these 105 consumers, 40 were excluded from the study because they attributed the same acceptance and purchase intention to all stimuli (probably because they were not paying attention to the stimuli or simply responded quickly to the questionnaire), behavior that is not accepted in conjoint analysis. In addition, 7 consumers did not complete the final stage of the study (projective mapping) and were also excluded from the subsequent analysis. As a result, 58 consumers' responses were considered valid and were statistically analyzed. Note that, despite the total amount of responses, only 37.17% of them were effectively analyzed. This is a consequence of the inherent lack of control in internet-based studies, which certainly needs to be explored in detail in further studies (Baptista, Valentin, Saldaña, & Behrens, 2021).

From the 58 consumers considered in the present study, 28% were men and 72% women aged 19 to 33. Regarding frequency of consumption, 14% reported consuming guava juice once every 15 days, 47% once per month while the rest reported less frequency of consumption. It is likely that because the study was internet-based, the consumer group was mostly composed of young individuals with undergraduate educations that had not obtained graduate degrees.

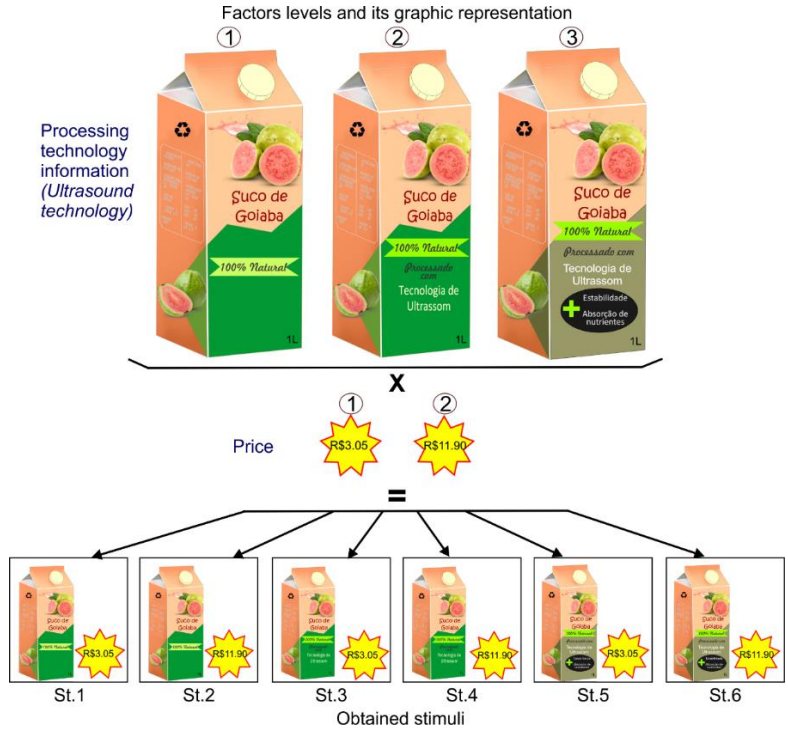

Figure 1. Representation of the factor levels (described in Table 1) and the obtained stimuli, which were evaluated by consumers.

Table 1
Factors and levels adopted in the conjoint analysis design

Factors	Levels and description
Processing technology information: ultrasound technology	1. Without statement of technology 2. Processed with ultrasound technology ("*Processado com tecnologia de ultrassom*"). 3. Processed with ultrasound technology, for better stability and nutrient absorption ("*Processado com tecnologia de ultrassom para maior estabilidade e maior absorção de nutrientes*")
Price*	1. Low (*R$ 3.05*) 2. High (*R$ 11.90*)

*The Price was presented in R$, the official currency of Brazil. The equivalent prices in dollars at the time of the study were low (US$ 0.93) and high (US$ 3.62).

2.2 Stimuli

We refer to "stimuli" as each product package created by combining a level of ultrasound technology with a price level. The stimuli used in this study were elaborated following a complete factorial design. The factors and levels used to create the stimuli were chosen according to the objectives proposed by the researchers and the scientific literature (see Table 1).

The "ultrasound technology" factor, comprised 3 levels: (1) Without statement of technology, (2) With statement of technology, and (3) With statement of technology and specification of its benefits. The benefits declared in our study were set up based on previous studies conducted by Aguilar, Garvín, Ibarz, & Augusto (2017); Campoli et al. (2018); (de Souza Carvalho et al., 2020); Khandpur & Gogate (2015); Rojas et al. (2016), who reported that ultrasound technology improves both the physicochemical and nutritional properties of fruit juices.

The "price" factor was chosen in the light of previous work that demonstrated its importance in consumer behavior (de Andrade et al., 2016). The levels of this factor were established based on the prices of processed fruit juices available in the local markets (Piracicaba, SP, Brazil), and comprise two levels: (1) Low and (2) High. Therefore, the full factorial design (3 levels of the "ultrasound technology" factor and 2 levels of the "price" factor) totaled 6 stimuli. The stimuli were designed using CorelDraw Home & Student X7 software (Corel corporation, Ottawa). For the sake of clarity, Figure 1 shows the levels of the "ultrasound technology" factor, the levels of the "price" factor and the six stimuli displayed to the consumers.

2.3 Experimental procedure

First, consumers reported their sociodemographic characteristics and consumption frequency of guava juice. Subsequently, visual stimuli (Figure 1) were presented to the consumers in a monadic sequential way, following a Williams Latin square design, coded with 3 random numbers using the Compusense Cloud software (Compusense Inc., Guelph, Ontario, Canada). For each stimulus, consumers were asked to indicate their expected acceptance using an unstructured 10-cm hedonic scale that ranged from "disliked extremely" on the left to "liked extremely" on the right. They then rated their purchase intention using a categorical 5-point scale ranging from "definitely would not buy" on the left until "definitely would buy" on the right.

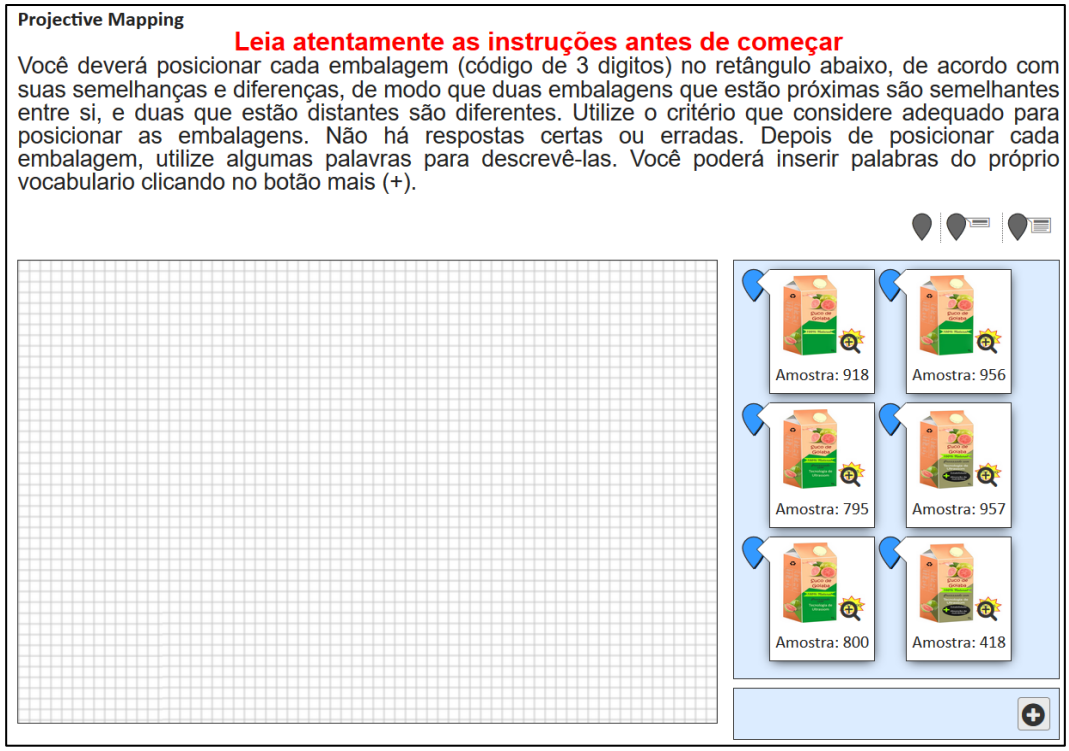

Figure 2. Screenshot of the projective mapping, as displayed to consumers.

Finally, a projective sensory test called projective mapping (Varela & Ares, 2012) was applied to find the holistic perception generated by the stimuli in the consumers (Figure 2). In order to do this, all stimuli were displayed on the right side of the screen accompanied by a superior text expressing the following: "Read the instructions carefully before starting. You must position each package (3-digit code) in the frame rectangle, according to its similarities and differences, so that the packages that are close are similar to each other and those that are far apart are different. Use the criteria you consider appropriate to group the packages. No correct or incorrect answers. After placing each package, use words to describe them. You can add words from your own vocabulary by clicking on the button ⊕". In addition, consumers were instructed to use the entire surface area of the rectangle. For a better visualization of the stimuli, consumers were able to enlarge these stimuli by touching the magnifying glass twice.

2.4 Data analysis

Expected acceptance and purchase intention of the stimuli were evaluated based on the analysis of variance (ANOVA) considering stimulus, consumer, and order of presentation of the stimuli as sources of variation. Also, the Tukey test was used for pairwise comparison at 5% of significance.

For conjoint analysis, the relative importance of each factor and the utility associated with each level were determined. In accordance with Lima Filho, Della Lucia, Lima, & Minim (2015), in order to determine the utility of each level of a given factor, an individual additive model is used, in which the factor contributions are summed up to generate the overall acceptance or purchase intention. The structure of this model, for m_j factors and m_j factors and n levels, is shown in Equation 1.

$$Y = \sum_{i=1}^{n} \sum_{j=1}^{m_j} V_{ij} X_{ij} + \varepsilon_{ij} \quad (1)$$

where, Y is the expected acceptance or purchase intention for each stimulus, V_{ij} is the utility corresponding to the j-th level of the i-th factor (i = 1, 2, ... n and j = 1, 2, ... m). X_{ij} is the variable indicating the presence of the j-th level of the i-th factor in each stimulus and εij is the unobservable random error of the model. Once the utility of each level is determined (Vij), the relative importance of each factor expressed in percentage, according to Equation 2, was determined.

$$RI_m = \frac{I_n}{\sum_1^2 I_n} \cdot 100 \quad (2)$$

where, I_n is the importance of the i-th factor. The sum of the importance for all factors should be 100% (Raz et al., 2008).

The data obtained from the projective mapping were analyzed using multiple factorial analysis (MFA) (Escofier & Pages, 1990; Pagès, 2005). First, having as origin of the coordinates the lower left part of each perceptual map, coordinates from each stimulus of each consumer were obtained. In addition, ellipses were built at 95% confidence by parametric bootstrapping to evaluate the stability of the configurations using the script provided by Dehlholm (2014).

Analyses were carried out in the R environment by using *lmerTest* (Kuznetsova, Brockhoff, & Christensen, 2016) for the ANOVA of the expected acceptance and purchase intention. Also, *Conjoint* (Bak & Bartlomowicz, 2018) package was used to estimate the utility and relative importance of conjoint analysis, and *FactoMineR* (Le & Worch, 2014) to perform the MFA on projective mapping results.

3. Results and discussion

3.1 Expected acceptance of guava juice

The relative importance of each factor as well as the utility of each of its levels on the expected acceptance is presented in Table 2. Overall, consumers gave more relative importance to the factor "*Processing technology information: Ultrasound Technology*" than the factor "*Price*". On the one hand, the utility indicates the influence that each level of a certain factor has over the expected acceptance. Thus, the factor and level of greater positive influence on acceptance was the "*Processing technology information: Ultrasound Technology*" showing the benefits of this factor (i.e. *level 3*, represented by a 57.17% of importance and 0.239 utility). Furthermore, the factor "*Price*", showed a lower relative importance (42.83%), where utility value for each price level was the same for both but with the opposite sign. It suggests that the lower or high price influence at the same intensity in a negative or positive way over the acceptance, respectively. In the case of the lowest price level, it presented the least influence on the expected acceptance of the guava juice, showing that the consumers put the price factor at a lower priority compared to the other studied factor.

Table 2
Values of importance for each factor and utility for each of its levels in the expected acceptance of guava juice

Factors	Levels	Utility	Relative Importance
Processing technology information: Ultrasound technology	1. Without information	-0.256	57.17%
	2. Reporting the used Technology	0.017	
	3. Reporting the used Technology and it benefits	0.239	
Price	1. Low	-0.054	42.83%
	2. High	0.054	

Figure 3 shows the average expected acceptance for each stimulus. Clearly, stimulus 5 holds the highest expected acceptance as a consequence of ultrasound technology benefits and low price. Note that its label displayed the message: "the processing of guava juice with ultrasound technology causes greater stability and absorption of nutrients". On the other hand, the price presented a lower relative importance (Table 2).

The above trends might be related to the fact that stimulus 5 displays the benefits of ultrasound technology, inducing a better assimilation of the given statement, which in turn results in greater expected acceptance. These results are in agreement with previous studies suggesting that the declaration of health benefits is one of the main determinants of consumer preference (Ares, Giménez, & Deliza, 2010; Balatsas-Lekkas et al., 2020; Romano, Rosenthal, & Deliza, 2015). Indeed, the expected acceptance of emerging technologies has been previously evaluated for High Pressure Technology (Deliza et al., 2005; Deliza et al., 2003), Pulsed Electric Fields (PEF) (Jaeger, Knorr, Szabó, Hámori, & Bánáti, 2015), and the irradiation method (Galati, 2019). Overall, these authors agree that consumer acceptance relies on the presentation of relevant information about the technology, while ignorance of the benefits of the proposed food technology can limit acceptance.

Nevertheless, the acceptance of emerging food technology is still a complex phenomenon. One of the main reasons is that, according to Siegrist & Hartmann (2020), consumers tend to have limited nutrition knowledge, and scarce knowledge about food production. As explained by Meijer et al. (2021); Zheng, Bolton, & Alba (2019), there is a multi-dimensional resistance which strongly influences the acceptance of food technology. In this sense, it was reported that the acceptance of non-conventional food technologies, such as food irradiation and genetic modification is driven by consumer knowledge whereas the resistance is attenuated by interventions remedying knowledge deficits. This is in agreement with our results, which indicate that the more information that is presented, the greater the expected acceptance.

Indeed, our results agree with a trend that has been increasing in recent years: "young consumers are increasingly concerned about their health", seeking a better quality of life (Watson, 2015). In fact, it has been demonstrated that younger consumers are more inclined to accept products treated with emerging technologies (Galati, 2019). Faced with that tendency, Vidigal, Minim, Carvalho, Milagres, & Gonçalves (2011) evaluated the influence of information on health benefits in the acceptance of açaí, camu-camu, cajá, and umbru juices. Their results indicated that health claims increased the acceptance of juices, although, the effect was not significant for consumers of camu-camu juice. On the other hand, our results show that the higher price presented a higher relative utility, which may be a direct consequence of high prices being associated with high quality (Jaeger, 2006).

Table 3
Values of importance for each factor and utility for each of its levels in the purchase intention of guava juice

Factors	Levels	Utility	Relative Importance
Processing technology information: Ultrasound technology	1. Without information	-0.158	49.73%
	2. Reporting the used Technology	0.04	
	3. Reporting the Technology used, and it benefits	0.118	
Price	1. Low	0.078	50.27%
	2. High	-0.078	

In addition, the acceptance of a product does not directly commit the money used for the acquisition of a good or service. That is, consumers are tolerant of a high price (positive utility, Table 2) when it comes to acceptance, probably because the acceptance of a product is not related to the amount of money they would have to pay, but to the overall quality of a product that had already been acquired. In fact, high price is usually correlated with high quality (Martin, 2017). Therefore, the "price" factor, plays different roles (positive or negative). In other words, for some consumers, prices can play a positive role due to the inference that the price level is positively correlated to the perception of product quality (Erickson & Johansson, 1985; Lichtenstein, Ridgway, & Netemeyer, 1993; Martin, 2017).

3.2 Purchase intention of guava juice

Concerning the purchase intention of guava juice, the relative importance of each factor associated with the utility of their levels is shown in Table 3.

When compared to the observed behavior in expected acceptance, the purchase intention was slightly influenced by the factor "*Price*" presenting a relative importance of 50.27 %. Due to this fact, the low level presented a positive utility of 0.078. Therefore, a high price negatively influenced the purchase intention of the product, since it is closely related to spending money. The "*Processing technology information*" factor was slightly less important than the "*Price*" factor. In addition, the level that shows the benefits of ultrasound technology presented the highest utility (0.118).

Figure 4 shows the purchase intention of the stimuli. The stimuli 5, 3 and 1 presented the greatest purchase intention. These stimuli were the lowest priced. Comparing the expected acceptance and purchase intention results, it can be observed that there is a similar trend, i.e. the products with the most expected acceptance also obtained more purchase intention.

Concerning acceptance, it is worth mentioning that the most important factor was "*Processing technology information*" whereas for purchase intention the factor "price" was the most important. This is a consequence of there being, in purchase intention, an amount of money directly committed, so that the consumer must decide between a low price and a high price. According to the utility of each level, the low price increases the purchase intention of the stimuli. Regardless of the levels of "*Processing technology information*", stimuli with lower prices had greater purchase intention. This behavior was expected and highlights the importance of the inclusion of the Price Factor in the conjoint analysis.

Based on these results, consumers appreciate and accept the positive effects of US displayed on the label. However, a high price could decrease their purchase intention, being therefore, the three stimuli that showed lower prices, the products with high intention to purchase (Figure 4). Furthermore, the groupings made in the projective mapping help to better understand the holistic perception of consumers.

According to Figure 5, the main criterion for grouping the stimuli was the processing technology shown in the stimuli. This coincides with what was previously observed, in which this factor was the most important for expected acceptance. Additionally, the purchase intention shares equal importance with the price. Samples lacking information about the "*Processing technology information*" were located in the fourth quadrant, whereas the samples containing such information were located in the second quadrant. Moreover, those displaying both information of processing and advantages were located in the third quadrant. Note that the consensus configuration considers the projection of all consumers. However, each consumer perceives and projects their stimuli individually since they have the freedom to use their own criteria. Thus, variations in their responses expressed in different perceptual maps are expected (Vidal et al., 2016) due mainly to the cognitive style used in the projective task (Varela et al., 2017). These variations are evidenced in the confidence ellipses shown in the next section.

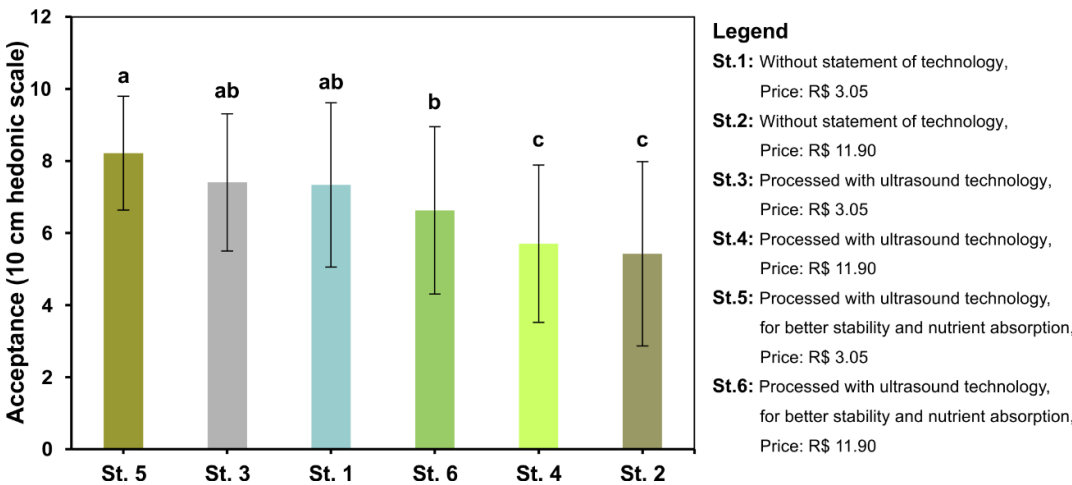

Figure 3. Average acceptance level. The different Letters indicate significant differences among stimuli according to Tukey's test ($p < 0.05$).

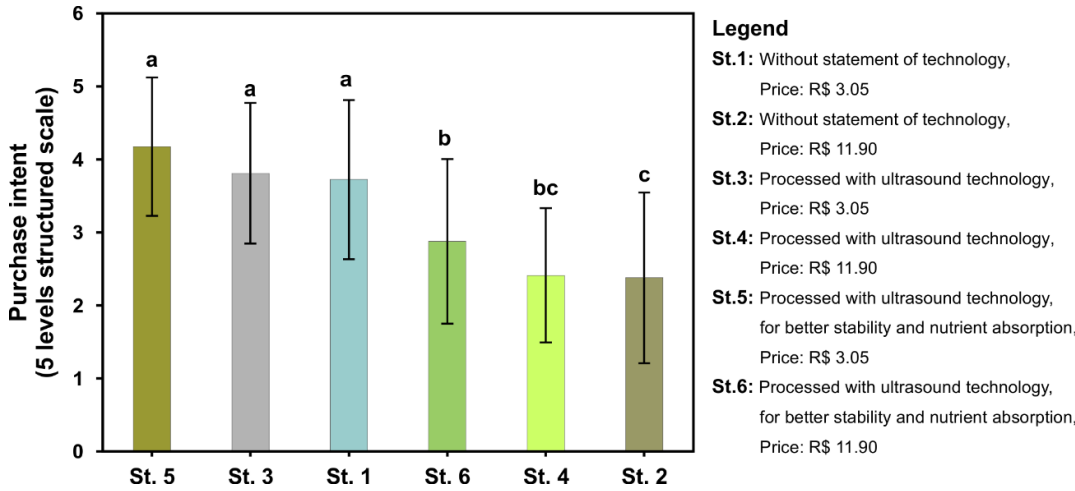

Figure 4. Average purchase intention. The different Letters indicate significant differences among stimuli according to Tukey's test ($p < 0.05$).

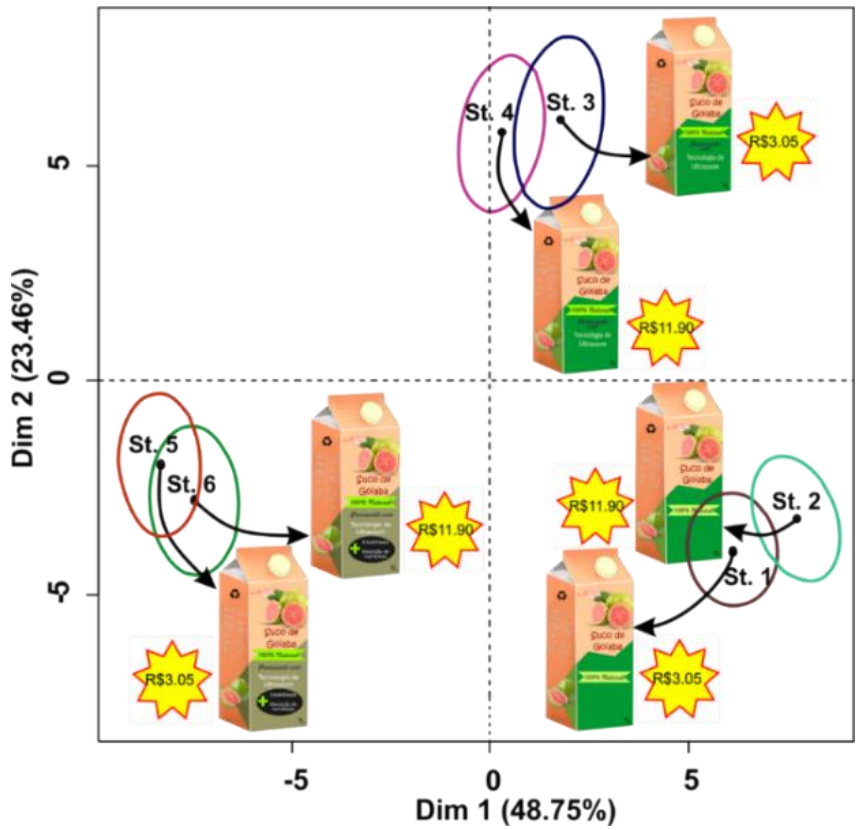

Figure 5. Spatial distribution of the 6 stimuli showing their ellipses of confidence.

3.3 Projective mapping

Figure 5 shows the holistic representation of the 6 stimuli considering the two first dimensions (72.12 % of the variance) of MFA. According to the confidence ellipses there are 3 different groups. Each group is composed of stimuli with the same level of the "*Processing technology information*" factor. Therefore, the criterion of grouping stimuli was based mainly on this factor. Overall, one can argue that the visual aspect helped in the grouping process.

Although the sensory variability is evidenced in the confidence ellipses, a detailed study of consumer segmentation is beyond the scope of the present study. In this regard, it can be said that, for some consumers, an important criterion of grouping could have been the price, but the observed response of all consumers indicates that the *"Processing technology information"* factor predominated. This promoted a faster and more intuitive response during the grouping of stimuli by holistic consumers, who processed the information quickly.

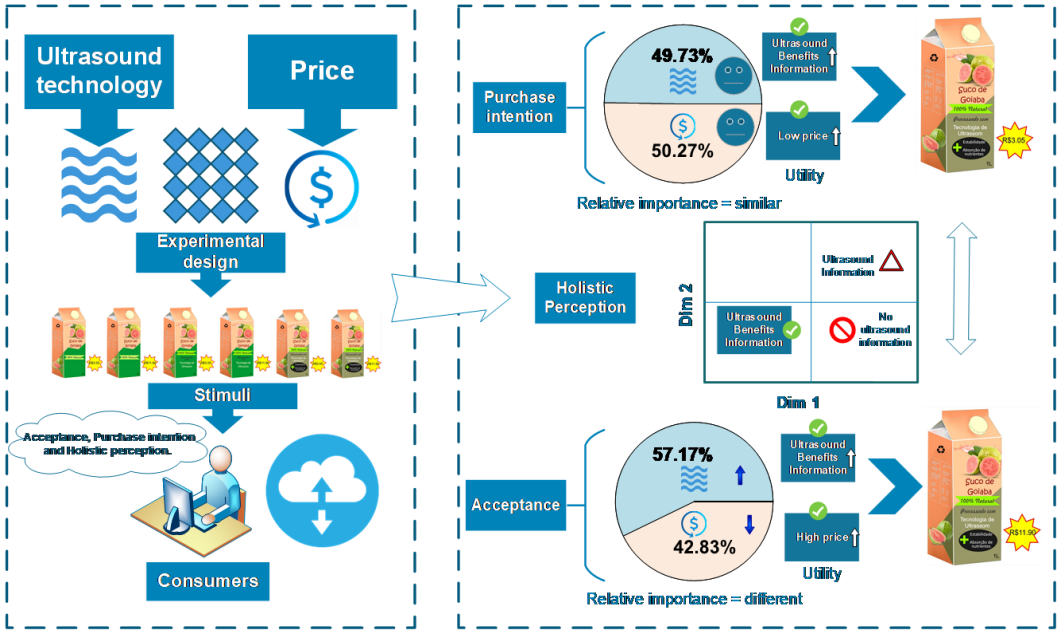

Figure 6. General representation of the conducted study, the method and remarkable results are shown.

Based on the results, it is likely that this group of consumers predominated, evidencing a reduced group of consumers that take more time to analyze price levels. These results reinforce the idea reported by Varela et al. (2017), in which different groups of consumers may have a different representation of the similarities/differences of the samples. Regarding the confidence ellipses for each stimulus (see Figure 5), stimuli that present similarities were observed to overlap each other. Also, considering their amplitude, it is inferred that for all the stimuli there was almost the same variation between the opinions of consumers.

3.4 General discussion and final remarks

In general terms, the factor "*Processing technology information*", which displayed the use of ultrasound technology, contributed positively to consumer acceptance regardless of the high price, as it shows a positive utility. This behavior might be correlated with the younger consumers enrolled in this study, since younger consumers are more concerned about health and are more receptive to innovative foods. On the other hand, the purchase intent increased with the lower price. But also, the "*Processing technology information*", proves to be important since both factors showed similar relative importance. In addition, this factor was also the main criterion for grouping the stimuli under study (Figure 6). Therefore, the best package labeling which obtained both the highest expected acceptance and purchase intention was Stimulus 5, which displayed processing technology information and its benefits, in addition to having a low price. However, results based on utility indicate that in products displaying information and benefits, price is a background factor in terms of expected acceptance. This indicates that as long as information and knowledge is given to consumers, products have the opportunity to be accepted even at high prices (Figure 6).

As for recommendations, we encourage the realization of further studies that go beyond internet-based questionnaires, increasing considerably the number of participants, adding other study factors, and combining intrinsic factors with extrinsic factors in processed products that are treated with ultrasound technology. Overall, the results suggested, from a consumer perspective, a promising future for the use of ultrasound technology in juice processing.

4. Conclusions

The product price along with the "*Processing technology information*" relative to ultrasound technology in the guava juice label had a significant impact on the expected acceptance and purchase intention of consumers. Thus, consumers granted higher acceptance to the products displaying the processing technology details and its benefits, regardless of the high price. The purchase intention was essentially defined by the "*price*" factor, however, the label information that highlights the ultrasound processing technology positively influenced the purchase intention as well. Moreover, the information displayed on the label is also one of the main criteria for grouping. The fact that the juice was processed with ultrasound technology did not have a negative effect on either the expected acceptance or purchase intention. These results could be used as a basis for future research on consumer behavior towards the usage of emerging technologies in food processing. We recommend the realization of further studies that go beyond internet-based questionnaires, increasing the number of participants and adding other study factors in processed products that are treated with ultrasound technology or other emerging technologies.

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